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Converting between units

Technique sheet

Problem-based learning resources

What do the different numbers mean?

In mathematics numbers are just numbers, they have no other meaning. Everywhere else numbers are measurements of sizes or quantities or are used as codes to identify things. In a specification list for an engineering project you will see quantities and measurements.

This list shows the parts needed to make a clamp. The flag is a code to identify the part quickly. The quantity is how many of each you need just a number but in the top line where it says 1, it means 1 base and for flag 10 where it says 2 it means 2 M6-1.0 hex nuts. However, there are also measurements. Flag 3 is a 300mm threaded rod.

Sometimes the units are not shown because they refer to standards. Flag 11 is a $1/2 \times 0.875$ music wire spring. By convention these springs are measured in imperial units, so $1/2$ means it has a diameter of $1/2$ inches. The 0.875 is how strong the spring is how many Newtons of force are needed to compress the spring 1mm.



Parts List

Flag	Part	Material	Qty
1	Base	Aluminium	1
2	Blade holder	Aluminium	1
3	7/16-14 x 300mm threaded rod	Steel	2
4	7/16-14 hex nut	Steel	6
5	Razor blade	Steel	1
6	M3-0.5 x 25mm socket cap screw	Steel	3
	M3-0.5 hex nut	Steel	3
7	Razor blade back plate	Steel	1
8	Razor blade clamp	Steel	1
9	M6-1.0 x 30mm socket cap screw	Steel	2
10	M6-1.0 hex nut	Steel	2
11	1/2 x 0.875 music wire spring	Steel	2

What are the most common units?

So that engineers and scientists can easily compare the sizes of things, standard units are used across the world. The most common are the International System (S.I.) units. The SI unit of length is the metre (m) and the SI unit of mass is the kilogram (kg). To measure larger or smaller amounts you can divide or multiply these by 1000. So, to get a measure in grammes multiply the value in kg by 1000. To get a result in metric tonnes divide the value in kilograms by 1000. It can be a bit confusing – just remember the smaller the unit the more of them you will have for a given object. A 1 kg bag of sugar weights 1000g but only 0.001 Metric tonnes!

In the clamp above they said for Flag 3, a 300mm threaded rod is needed. They could have used:

$$300\text{mm} = 300/1000 = 0.03\text{m}$$

$$300\text{mm} = 300/10 = 30\text{cm}$$

- Make sure you can convert measurements into different forms (e.g. g to kg, nanometres to centimetres) to make handing them more convenient.

Modifier	Multiply by	Common name
tera	10^{12}	Trillion
giga	10^9	Billion
mega	10^6	Million
kilo	10^3	Thousand
hecto	10^2	Hundred
deka	10^1	Ten
deci	10^{-1}	Tenth
centi	10^{-2}	Hundredth
milli	10^{-3}	Thousandth
micro	10^{-6}	Millionth
nano	10^{-9}	Billionth
pico	10^{-12}	Trillionth

What other sorts of units are used?

In the S.I. system there are units for other quantities including electric current (Amps) and temperature (Kelvin) which work the same. For temperature, Celsius (or centigrade) ($^{\circ}\text{C}$) and Fahrenheit ($^{\circ}\text{F}$) are most familiar. Kelvin starts at absolute zero which is minus 273.15°C . So, just take away 273.15 to change Celsius into Kelvin. Fahrenheit is old fashioned and used mostly for the weather.

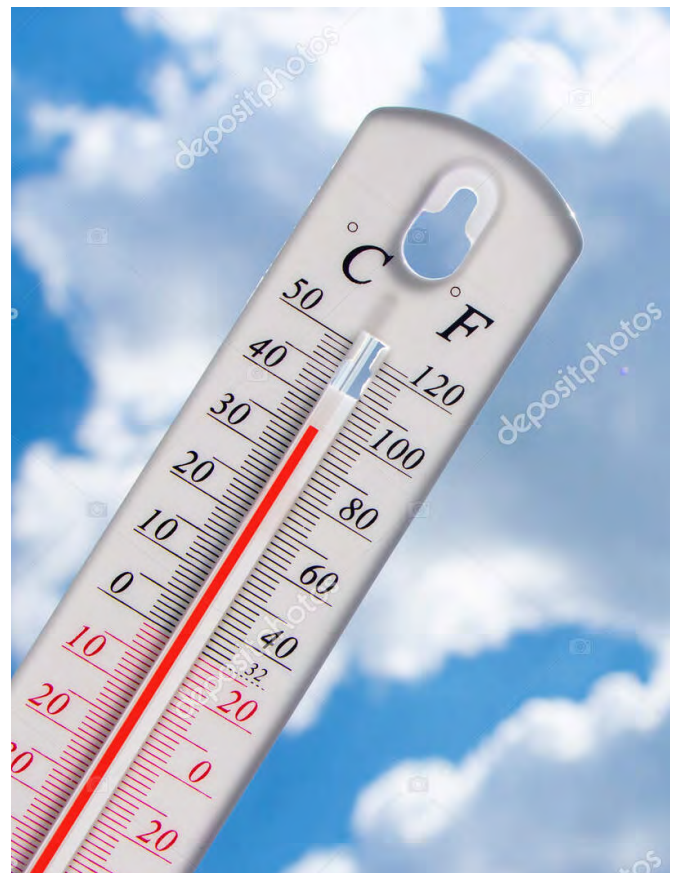
To go from Fahrenheit to Celsius take away 32, divide by 9 and multiply by 5. To go the other way multiply by 5 but divide by 9 – and then add 32! It's complicated!

The unit for time (seconds) works differently. We know there are 60 seconds in a minute and 60 minutes in an hour and then 24 hours in a day.

- Make sure you can work with all the units you will come across in your work – some applications use old-fashioned or non-standard units.

What are Imperial Units and how do you convert?

In the United Kingdom there was a different set of units called Imperial Units. The American version are called US Customary units. In the clamp design, the diameter of the spring was measured in inches – an Imperial measure. There are 12 inches in one foot, three feet in a yard and 1,760 yards in a mile. For mass, the ounce (oz) is about 28 grammes. Then 16 ounces make one pound (lb). 14 pounds make one stone and 2,240 pounds make an Imperial ton. The biggest difference in the US is that a ton is 2000 pounds. You can see why most engineers use S.I. units! For historical reasons most people in the UK know their own height in feet and inches and weight (mass) in pounds and stones. Many recipes give quantities in pounds and ounces. So, it is necessary to know some conversion factors.



You can easily find conversion factors for any units on the internet and many scientific calculators have them built in. So, look up the ones you need at the accuracy that you need.

For example, the spring in the clamp is $\frac{1}{2}$ inch. That is 0.5 inch. 1 inch = 25.4 mm

$25.4 \times 0.5 = 12.7$. So, the spring has diameter 12.7mm

If you are not sure whether to multiply or divide, have in mind roughly what you expect before you do the calculation. If you chose wrong, your answer will be wildly wrong and you will know.

The cliff railway will originally have been specified in feet.

You can find 1 foot = 0.305 metres

(*Think:* that's roughly 3 feet to the metre so 30m is roughly 90 feet.)

$30 \div 0.305 = 98.36$ to two decimal places.

The cliff railway is 98 feet high to the nearest foot. What would happen if you used feet for the railway track but then ordered the same length of steel in metres? You'd end up with 90m of steel rail – roughly three times the amount you need! And three times the cost!

Make sure you do not mix units from different systems (e.g. SI and Imperial). You will end up with the wrong answer!



Check yourself

You should be able to answer these questions easily after reading this sheet.

1. Which units are used most often by engineers? Why?
2. How can you convert between inches and metres?
3. Why should you not mix units from different systems in a calculation?



Taking it further

These activities will deepen your understanding of this topic.

A good engineer should be able to make a sensible approximation of the size of objects and lengths of time and distance.

Guess the mass of different objects made of different materials and then measure them. Guess how long you have been alive in minutes. Then work it out! Ask yourself questions about size and then research the answers.

What is the mass of a large passenger aircraft? How far is it to Mars? What is the diameter of a human hair? How close can you get?